XX. *On the Parasitical Connection of Lathræa Squamaria, and the peculiar Structure of its Subterranean Leaves: in a Letter to Robert Brown, Esq., F.R.S. V.P.L.S. By J. E. Bowman, Esq., F.L.S.*

Read November 3, 1829.

The study of Vegetable Physiology, comprehending the affinities and properties of plants, and the relation they bear to the animal kingdom, constitutes, doubtless, in every point of view, the most important as well as the most delightful branch of botany, and claims for it a rank among the natural sciences, to which it would not be intitled, if confined merely to nomenclature and system. Though the general laws which govern the structure and œconomy of vegetables be now tolerably understood, there are many deviations from them, which offer to the philosophic botanist subjects peculiarly worthy of his study and investigation. Here a vast and almost unexplored field lies before him, where analogy can contribute little assistance, and where his progress must be proportionably slow and unsatisfactory.

Perhaps the most striking exceptions to the prevailing laws are found in the tribe of parasitic plants, whether they be Phænogamous or Cryptogamous. Having in the course of the last and present season detected some interesting peculiarities in an individual of the former of these divisions, the *Lathræa Squamaria* *, which

* It is suspected that we have two British species, or at least varieties of this plant. I have in Loudon's *Magazine of Natural History*, vol. 1. p. 105, stated the differences between

which I believe to be new to botanists, I venture to lay them before the Linnean Society.

I regret that my attempts to investigate the germination of the seeds and the character of the cotyledons have not yet been fully satisfactory. The two last seasons I sowed the seeds between dead leaves, in pots filled with the soil in which the plant grows, and placed them in its native situation: but in both instances they failed to germinate; at least they still remain inactive. Neither have I been able, by dissection, to trace any division of the cotyledons. However, in one of my attempts to ascertain the parasitical connection of the plant, I detected among the mass of roots, when cleared from the soil, what proved on examination to be a minute embryo. This I have represented, both of the natural size and also in two positions highly magnified, at Tab. XXII. Fig. 1. *a*, *b*, *c*. Though the cotyledons

between our Welsh plant, and that figured in *English Botany*, tab. 50, and the description in *English Flora*, vol. 3. p. 128; to which I may add, that all the specimens which have afforded the materials of the present paper, have the upper lip of the corolla *entire*, or very slightly notched; while in the authorities just quoted, it is represented as *deeply cloven*. In Curtis's figure (*British Entomology*, vol. 4. tab. 160) it is undivided. The height of the flowering stems, in favourable situations, is even more gigantic than I have stated in Loudon's *Magazine*, being sometimes 15 or even 18 inches, bearing from 50 to 60 flowers; on one I counted 63. The subterranean stems are often from 2 to 3 feet long, surrounded at intervals of 5 or 6 inches by thick irregular whorls of cylindrical, often forked branches, closely beset with scales; and it is often in these parts so swollen and distorted, that it can with difficulty be traced through the labyrinth. Its usual habit is horizontal, producing at the upper whorls, 1, 2, or 3 flowering branches, which are the only parts that ever emerge into day; and it sometimes happens, that the whorls which bear them one season throw up none the next, and *vice versâ*. New branches are added to the subterranean stems every season, and the extremities of the old ones are lengthened out by fresh shoots, both being clothed with a delicately white and succulent herbage, which is permanent and never renewed. Tab. XXII. Fig. 2. is decisive as to their perennial character, the smaller scales just above the crown of the root (*a*) being evidently those of the embryo plant.

unfortunately

unfortunately are not in a perfect state, their situation and footstalks are sufficiently apparent, and refer it to the Dicotyledonous family*. The four scales and the radicle were perfect; but from the minuteness and delicacy of the embryo I could not satisfy myself whether the larger rudiment of the cotyledon consisted of the petiole only, or the decaying and collapsed state of the whole lobe. Those most conversant with the compound microscope can best appreciate the difficulty of correctly defining such minute objects amid the deceptions arising from the discordant reflections and evaporations of the fluid employed, and of the surrounding lights and shades. From viewing it in different directions and in a variety of lights, as well as from the close resemblance of its scales in shape and texture to those of the perfect plant, I was however assured of its being an embryo *Lathræa*, before I noticed the solitary tubercle near the extremity of one of its radical fibres. This determined me, in the absence of its more complete development, to take the sketches already referred to, though I lay them before the Linnean Society with less confidence than any other in the series of drawings which elucidate this paper.

After many ineffectual attempts, I at length succeeded in obtaining specimens of the *Lathræa* with its real original root; and this part so satisfactorily helps us to understand the early growth of the plant, that the failure of observations on the germination of the seeds is the less to be regretted. I caused a circular trench, about two feet in diameter, to be dug round the

* The oily nature of the seeds, and the uniform ligneous reticulated fibre in which the sap-vessels of the subterranean stem are interspersed, though without a concentric arrangement, support this view: but I do not think the sap-vessels have a spiral structure. The bark consists of a simple cuticle, and a broad circle of spongy cellular tissue, which ranges round the woody fibre, and occupies more than half of the radius of the stem.

flowering stems of a young plant, carefully cutting and sawing off all the roots of the Ash-tree (under which it grew) that came in contact with the spade, without disturbing the central mass. When the trench was sunk lower than the horizontal roots of the tree, I caused the labourers to undermine the insulated lump on all sides, and to lift it carefully into a large garden basket, in which they carried it into a neighbouring and rather rapid stream: here, by repeated and cautious agitation, I at length washed away all the soil, leaving exposed the roots and fibres of the Ash, and the subterranean stems of the *Lathræa* completely matted and entangled together. On separating them, I had the satisfaction to find the parasite with its root, of the size, shape, and habit represented in Fig. 2. This clearly shows its true character, and solves the problem, that though its base is not inserted into the stock, as in *Orobanche*, but is spindle-shaped and terminates in many forked fibres, it is strictly parasitical, each fibre being furnished with very minute tubercles, which fix themselves on the roots of the tree to extract their juices. It is only by means of these that the fibres can perform their office of ducts. As these tubercles are also copiously found on the fibres of the subterranean stem, and will be best described with it, I shall for the present defer the detail of them, noticing only two or three of an extraordinary size, which may be seen in Fig. 2. *b*, on the upper part of the caudex of the root. These are of a much firmer and more woody texture than the smaller ones, and their interior organization is more complex, though they perform the same functions. A magnified longitudinal section of one of them is shown in Fig. 4; but it will be better understood hereafter. The exterior of the caudex is of a red-brown, and tolerably smooth; its texture is solid and woody. A cross section of it exhibits very numerous *angular* cells connected by a fibrous network, which forms the solid portion.

It

It is evident from an inspection of Fig. 2, that in an early stage of its growth the embryo-stem, contrary to the almost universal rule, *avoids the surface, and takes a downward direction in common with the root.* The intention of this is sufficiently apparent; for when once it finds itself among the roots and fibres of the tree, it no longer continues to descend, but spreads *horizontally*, fixing its tubers upon them, and commencing its attacks on every hand. This is one of those instances of adaptation effected in direct opposition to an established law, which fills us with unceasing wonder, and cannot fail to exalt our views of the Mighty Author of Universal Nature. A necessary consequence of the downward tendency of the young stem is, the contrary direction of the flowering branches, one of which is shown at *c*, in Fig. 2, evidently seeking its natural element, the atmosphere. They are invariably curved at their base till they acquire a perpendicular position, and are the only portion of this singular plant which ever appears above the surface of the soil. As this takes place before the trees acquire their leafy honours, it weakens the opinion, that their unnatural and sickly hue is owing to a deficiency of light.

It seems probable, from the sound and healthy appearance of the root, and from the large tubers on the caudex being in full activity, that it continues for many years; at all events, that it does not decay as soon as the smaller tubers of the stem have begun their operations. Yet I have little doubt, that if it were possible to separate the root from the stems without disturbing them, they would receive adequate and ample nourishment from their own tubers to supply the flowering stems they respectively produce.

I shall now endeavour to describe the nature of the parasitical connection of our plant with some minuteness, as it has hitherto been

been very imperfectly understood. Its subterranean stem throws out from between the scales many succulent and tender fibres, bearing a profusion of minute tubercles or bulbs, which fix themselves upon the roots of the Ash, Hazel, &c. and extract their juices in the manner shown in Fig. 3. These tubercles are principally formed near the extremities of the fibres; they are either solitary or in groups of two or three, and bear some external resemblance to small beads, or the knotty excrescences on the roots of some leguminous plants. The connecting fibres are so tender, that it is difficult to get them up without breaking off the tubers, which are left behind upon the root of the stock. The tubers are brown, semiglobular, and succulent, and usually not larger than a small pin head; so that, even should a few remain on the fibres after being dug up, they might escape observation among the soil that adheres to them. Hence I attribute their having so long escaped the notice of botanists. Neither these tubers nor their fibres are to be found in the very spirited woodcuts of Matthiolus, Parkinson, or Gerarde*. Sir J. E. Smith (*English Flora*, vol. 3. p. 128.) alludes to the fibrous character of the root; but though he says he believes it to be parasitical, he does not explain in what way. On first washing the Ash roots, I was astonished to find some of them thickly studded with the tubercles adhering closely to the bark on all sides, and to the fibrous roots of the parasite, in the manner I have represented in Fig. 3. To remove all doubt on this head, I traced these fibres from the tubers to their insertion in the stem between the imbricated scales of the *Lathræa*, and, by the aid of the microscope, through its cellular bark to their junction with the ligneous part which ranges round the medulla. It was ne-

* The figure in Matthiolus is the largest and best of the three; but the flowers in all are too small, and too thinly scattered on the stem. The cut in Gerarde (edit. 1597) is a copy from Matthiolus, but reversed and on a smaller scale.

cessary

cessary to ascertain this, as many of the tree roots are constantly found entangled between the scales.

When the tubers are first formed on their fibres, they are nearly round (Tab. XXII. Fig. 5. *a*.), but after their attachment to the bark they become compressed and semiglobular. On being carefully removed, their under surface at the point of contact has an irregular warty appearance, arising more from the firmer texture of the vessels about to be described, than the almost gelatinous substance in which they are imbedded. These appearances are shown in the magnified figure 5, as is also the surrounding lacerated cuticle, which probably excludes the atmosphere in the soil from all interference with the process of unnatural exhaustion. Tab. XXIII. Fig. 1. & 2. represent highly magnified perpendicular sections of the tuber attached to the root of the Ash (of which latter, the portion shown is a transverse section). Fig. 2. represents it cut through longitudinally *in the direction* of its fibre: and Fig. 1. at right angles with, or *across* it. A reference to these will help the Society to understand its organization and functions. The tuber consists of a succulent and nearly homogeneous substance, showing only a cellular texture near its circumference, which gradually becomes more delicate interiorly, and in the central parts is entirely wanting. From its under surface, or point of attachment, it sends down a tap or funnel-shaped process, generally straight but sometimes curved, which penetrates through the cortical layers of the root to various depths into the alburnum, but never into the solid woody fibre. The tap does not send out any lateral auxiliary branches; but a single filament or duct passes through it, thickening in its progress upwards; and on its entering the body of the bulb dividing into several branches, each traversing its substance in a tortuous manner, and frequently intersecting the others, but finally approaching and unitedly

forming

forming a confused mass under the point in contact with the fibre. By this system of vessels the food of the parasite is doubtless alienated and conveyed along the root-like fibres into its subterranean stem; and from their dispersed and sinuous course within the tuber, it is probable the sap may there undergo a necessary change. These vessels consist of a close series of minute semi-opake oval bodies, and have a moniliform or beaded structure. Tab. XXIII. Fig. 3. shows a transverse section of a tuber and its central vessels.

Some of the many tubers I examined, differed materially from the rest, and deserve attention, from the light they appear to throw upon the nature of the action excited by parasites in general. The section Tab. XXIII. Fig. 4. is one of these; it is divided in the direction of the fibre and of the vessels of the Ash root on which I found it. The interior of the tuber was more densely and uniformly cellular than usual; and instead of the meandering group of beaded ducts in the centre, it had on each side, near its circumference, a separate set of anastomozing vessels, strong and darker coloured near their contact with the fibre, but becoming gradually paler and more delicate as they approached the middle and lower portions of the tuber. Each fascicle communicated with the fibre by a single detached trunk, and the spaces between a few of the larger reticulations only, were transparent; the remainder of the section being much more opake than in Tab. XXIII. Fig. 1. & 2. Here also was no trace of the funnel-shaped process; and the only symptom of derangement or disease in the bark and alburnum of the Ash root, was a number of small globules, mostly detached, but more closely congregated beneath the centre of the tuber. Both the funnel and dark anastomozing vessels just described, were wanting in other tubers; but they contained the transparent globules, which were also seen more perfectly formed in the alburnum underneath.

neath. One had a dark group of them under the fibre, but instead of a regular set of tortuous vessels through its centre, it had well-defined but mostly detached globules interspersed, and indications of a tap striking downwards into the alburnum. Several others had a tap in different stages of development, sometimes irregular and ill-defined. In some, the globules (which were filled with fluid) seemed to have formed fissures or cavities in the alburnum, similar to those in Tab. XXIII. Fig. 1. & 2; while many of the tubers were without either tap, beaded vessels, or the transparent globules, and consisted only of the delicate cellular substance already described.

I think it probable that all these, including the section Fig. 4, were tubers in the early stages of their action on the parent root; and that the globules interspersed in them and in the bark and alburnum underneath, with a central tendency, were preparing the way for the yet undeveloped inferior appendage or funnel. It is difficult to conceive how so delicate and succulent a substance can penetrate the comparatively hard bark and alburnum of the root, but by means of some chemical change, or corrosion effected by the union of their respective juices. The irregular fissures or cavities in the alburnum exhibited in Tab. XXIII. Fig. 1. 2. & 5, are generally present under those tubers which have pierced it with their funnels. The septa and parts immediately in contact are frequently brown and discoloured, indicating disease from being drained of their sap. They are always surrounded by a light-coloured border, as in the figures, probably a new layer of liber formed by the renovating power of Nature to check the progress of the morbid action. Beyond this border, the surrounding parts are constantly sound and healthy, the injured portion seldom extending wider than the space covered by the tuber.

I am inclined to think that the tubers are renewed annually, like

like the radical fibres of trees and perennial plants. This opinion is strengthened, from a larger portion of those which I have examined in October and November having had taps inserted into the returning vessels of the alburnum, than those I have examined in the spring, the greater number of which had short or imperfect taps, and were often without the interior system of beaded vessels. If a root on which they have fixed be carefully examined, some minute scars may be observed on the bark, each divided, by a straight fissure with prominent lips, into two equal parts. These are the cicatrized wounds caused by old and decayed tubers, some of which may be seen of the natural size on the broken extremity of the Ash root (Tab. XXII. Fig. 3. *a*); and a magnified transverse section of one, with the cavities within, surrounded by its margin of new liber, at Fig. 5.

The organization of the large tubers of the caudex differs from that of the small ones of the extremities, in having a more crowded system of beaded and nearly parallel vessels (instead of the central intersecting set of the latter) distributed through its whole substance. These vessels are intersected by a dark-coloured regular cone, in the situation represented in the longitudinal section (Tab. XXII. Fig. 4.), which seems to consist only of a more dense assemblage of the vessels themselves, and whose entire figure would be that of the concave bottom of a glass bottle. A cross section of this tuber exhibited its numerous vessels in detached spots. The tap was broken off in the root of the stock, but its situation is indicated by the letter *a*.

I now pass on to that portion of this singular plant from which it has severally been called *Dentaria*, *Squamaria*, and Toothwort, and whose true character seems to have puzzled both the older and more modern botanists; I mean the squamæ, or tooth-shaped scales. Matthiolus (*Comm. in Lib. quartum Dioscoridis*, p. 314. edit. Ven. 1583.) evidently took them for roots;

"*Radice*

"*Radice nititur albicante, magna, succosa, fragili, compactili squamarum congerie:*" yet it will scarcely be contended that his "*miro sane naturæ artificio elaborata*" refers to anything beyond their exterior appearance. Linnæus, Withering, Willdenow, &c., also call them roots; and the able author of *Vegetable Physiology* * considers them as "scaly appendages to the roots." Sir J. E. Smith in *English Botany* (vol. i. tab. 50.), and in his *Introduction to Botany* (chap. xii.), also calls them roots, though he was subsequently led (*English Flora*, vol. iii. p. 128.), from the analogy of this genus to *Melampyrum*, to refer them to their true character of a subterranean herbage. He seems nevertheless, incorrectly I presume, to confound them with the bracteas of the flowering branches, which he distinctly calls *leaves*. The idea of their being roots, though erroneous, was venial enough from their underground situation, and is probably as old as a knowledge of the plant itself. It has perhaps been perpetuated among botanists by a remark made by Linnæus, and alluded to by Mr. Brown in his very luminous paper on the *Rafflesia* (*Linn. Trans.* vol. xiii. p. 226.), "that the whole tribe of parasitic plants are distinguishable by the imperfect development of their leaves, and the entire absence of green colour." The learned author last quoted justly observes that plants parasitic *on roots* are chiefly thus distinguishable. This rule however is not universal, an exception being found in the genus *Cuscuta*; which, after the decay of its original root, has no connection whatever with the earth, but is nourished and supported solely by radicles fixed upon the *stems* of other plants. Many if not all of the foreign species of *Cuscuta* have a similar economy, and are destitute of leaves and of green colour; indeed I know of no plant without true leaves that is green. I

* No. XIV. of the Treatises published by the Society for the Diffusion of Useful Knowledge, p. 29. col. 2.

am therefore inclined to believe that the pale and sickly hue of such parasites, whether fixed on roots or stems, results at least as much from this circumstance as from the surreptitious nutriment on which they feed. The absence of true leaves constitutes one essential physiological distinction between *Cuscuta* and *Viscum*; and though *Listera Nidus avis*, *Monotropa*, and *Orobanche* are parasitic on roots, they are also destitute of leaves furnished with pores. All such plants are consequently incapable of drawing sustenance from the atmosphere, and of being acted on by the powerful stimulus of light, and can only derive the necessary supply of food through the medium of their lower extremities. It may be said that as they find their food ready provided for them by the stock on which they grow, leaves would be superfluous; and that Nature, in depriving them of these usual organs of assimilation, has, in the plenitude of her power, prepared it for them through the medium of a foreign source. But this does not explain the cause of the absence of green colour; indeed the instance of the Misletoe renders the reasoning inconclusive. This plant is perhaps more strictly parasitical than any of those just named, yet it is *green*;—a necessary consequence, as I conceive, of having *leaves*, though they be sparingly supplied with pores *.

I hope to make it appear that the *Lathræa* differs in structure from all the parasites just named; and that, though it be

* I have observed that the Misletoe dies with the tree on which it grows; and from a notice in the *Magazine of Natural History* (vol. ii. p. 294.), it seems that the *Lathræa* does so too. It has long been doubted whether *Listera Nidus avis* be strictly parasitical. Whatever it may be in the earlier stages of its growth, it certainly is not so in its more advanced state. If it be carefully got up in a clod, and the soil afterwards washed from around it, the base of the central root or caudex may be seen to terminate in a short curved spur, which tapers to a fine point, and evidently is not attached to any other vegetable. The cuticle of the stem and its bracteas has no perspiring pores.

parasitic

parasitic *on roots*, it is copiously supplied with *true leaves*, while it shares, in common with them, the appearance indicative of the want of those organs. Assuming for the present that the tooth-like scales of the subterraneous stem are really leaves, the apparent anomaly will be reconciled by reflecting that their functions are necessarily performed in the total absence of light, that essential agent in the production of the common livery of the vegetable kingdom. Neither is their cuticle perforated by any pores. In order to ascertain if light would produce any change, on the 20th of November last I carefully laid them bare and washed away the soil; but after having been as much exposed as their gloomy situation would admit till the middle of January, they had not acquired the slightest approach to a green colour, nor any absorbing pores. Frost now set in; and on again examining them on the 5th of February, I found the uncovered parts blackened and destroyed by this unnatural exposure. A head of flowers has since shot up within two inches of the spot, without any change in its natural appearance.

The general shape and character of the leaves, though they vary considerably in detail, are known to most botanists, and may be understood by reference to Tab. XXII. Fig. 2. & 3, and Tab. XXIII. Fig. 6. 7. & 8. If their outer or convex surface be viewed attentively by the naked eye, especially those on the newly formed branches, a number of longitudinal parallel striæ, or tubes, may be observed under the cuticle, whiter and more diaphanous than the contiguous parts, but having no apparent orifice or external communication. On dissecting the leaf, these are found to be so many hollow cells or chambers imbedded within its solid succulent substance; and varying in number from six to twelve according to the size of the leaf. A lens of moderate power shows their interior surface to consist of a variety of irregular corrugations or tortuous ridges, which increase the superficial area very considerably.

siderably. A longitudinal section of one of these cells may not inaptly be compared to the folds within the helix of the human ear; but its usual form may be seen in the magnified perpendicular section, Tab. XXIII. Fig. 7; and its cross section in Fig. 8. 10. & 11. The compound microscope shows every part of its surface to be lined with innumerable oval transparent glands or papillæ, some sitting, but for the most part raised on pedicels of various lengths, and all pointing towards the centre of the cavity. These glands are so minute as to be barely visible with the lowest magnifier of the compound microscope. Their situation may be seen in Fig. 10. & 11; and their shape, very highly magnified, in Fig. 12. They are marked by four longitudinal depressions, which indicate as many septa or valves within, the intermediate spaces being hollow (see *d.* and *e.* of Fig. 12.); but I have not been able to ascertain whether the apex of the gland, or the pedicel, be perforated. They have a very beautiful appearance under the compound microscope, either in a transverse section of the cell, or when the lining of the cell is viewed as an opake object. On account of their extremely delicate texture, they soon shrivel up as the section dries.

Though satisfied, from the elaborate structure of these secret chambers, that they were destined to perform some important office, and that they must, some way or other, have an exterior communication, it was not till after repeated observations and many tedious and unavailing efforts, that I had the good fortune to discover it. If the longitudinal section of the leaf and one of its cells (Tab. XXIII. Fig. 7.), or the more highly magnified part of it (Fig. 9.), be attentively examined, a very narrow interstitial opening or passage may be traced from *a.* inwards, between the incurved lower edge of the leaf *d*, and the underside of the leaf-stalk *e*, and leading into the inclosed wider space within, *b.* This inner space (a cross section only of which can be shown

in

in this figure) runs along the whole underside of the leaf beneath the course of the dotted line *a. b.* of TAB. XXIII. Fig. 6; and communicates, by means of an oblong narrow orifice (Fig 9. *c.*), with the bottom of each of the perpendicular leaf-cells. This appearance may be best detected in a very thin longitudinal section of the leaf placed under the microscope; and though the inner curvature of the leaf *d.* will sometimes adhere to the leafstalk *e*, and close the aperture, the application of a needle or bristle will immediately discover it. The cuticle of the leaves is destitute of pores on both its surfaces*. When highly magnified, it appears to be traversed by an irregular network of veins, the reticulations a little prominent, and connected by a transparent but strictly imperforate membrane.

Keeping in view this very curious and singular structure, I think its œconomy cannot be misunderstood; viz. that the squamæ or scales of the subterranean stem are *real leaves*, and that the prominent glandular papillæ of their interior cells perform the office of true cuticular absorbents. Under ordinary circumstances, leaves freely exposed to the action of the air and of light, and provided with a porous cuticle, receive carbonic acid gas into the cells of their parenchyma, where the oxygen is separated and thrown off, and the carbon assimilated with the hydrogen imbibed by the roots. But in the case of the *Lathræa*, where they are destined to perform their functions, not only in the dark, but buried in the earth, such an arrangement would have been inexpedient; it is therefore substituted by another,

* So is the cuticle of the flower-stem, the individual flower-stalks, the calyx, and both surfaces of the bracteas. The copious woolly hair on the flower-stem and calyx, when highly magnified, appears jointed like a bamboo cane, and tipped with a globular or oval summit; but I cannot ascertain whether they are perforated. The bracteas have neither the internal cells nor the bladders of the true leaves; but there are often several at the base of the flower-stem, of an intermediate character, being partly succulent and chambered like the latter, and partly thin and solid like the former.

admirably

admirably adapted to their peculiar circumstances and situation. Had the cuticle been furnished with air-valves, the soil would have continually clogged and impeded their office; they are therefore removed by a contrivance, as beautiful as wise, and placed within the convoluted chambers excavated for them in the interior of the leaf, where they perform securely and unseen their destined office. If it be doubted whether, from the unusual form and prominence of these papillæ, they are the real absorbents of the leaves, I would hint the probable advantage of some such arrangement to enable them more effectually to act upon the very small supply of air admitted into the cells, which is, moreover, always in a stagnant state. It will not, I think, be contended that they absorb *moisture* rather than *air;* and as this forms the grand distinction between *roots* and *leaves*, I trust I have satisfactorily proved them to be the latter; though, because their functions are performed in the dark, one material effect of these organs is not produced.

The succulent or solid portion of the leaves also deserves attention from its singularity of structure. It consists altogether of a framework of cellular substance, chiefly in hexagonal compartments, resembling a number of hollow dodecahedron crystals closely fitted together (see the sections, Tab. XXIII. Fig. 10. & 11.). Each cavity, besides the watery juice which fills it, contains several oval or pear-shaped and perfectly transparent bladders, quite detached from each other and from the sides of the cells, and lying over one another in an irregular manner (see Tab. XXIII. Fig. 13.). They are from their minuteness invisible to the naked eye, but exhibit a very curious appearance in a thin section of the leaf under the compound microscope. In one of these sections, placed between the talcs of an ivory slider in April 1828, they still retain their original shape and size; from which I at first concluded they were distended with air. Subsequent experiments

ments have, however, proved them to be filled with a glutinous or mucilaginous fluid of much greater specific gravity than water; in which, though no larger than particles of the finest pollen, they sink as freely as grains of sand. As they are not attached to the sides of the cells, they may be easily separated by macerating the leaf in water, and carefully removing the fecula with a camel-hair pencil, when they will be found at the bottom like a mass of impalpable particles of pounded glass. On evaporating the water, and submitting them to a very considerable dry heat, they still remain distended; but on bruising them with the flat side of a knife, they give out a fluid, which, though it becomes stiff and fixed by heat, almost immediately regains its viscidity by re-absorption from the atmosphere. From their extreme minuteness this experiment can only be tried by collecting the bladders in considerable quantity and examining the expressed fluid under the microscope. In pure alcohol they generally remain quiescent, not more than one in fifty, even of the smallest, ranging about like particles of pollen similarly treated. When held over a spirit-lamp, either in distilled water or in alcohol, they burst simultaneously, but the shrivelled transparent skins still lie at the bottom of the fluid. The mucilage diluted in alcohol retained its transparency; in distilled water it gave a red tinge to blue litmus paper, but did not affect the red litmus; and on dropping into it a little diluted sulphuric acid, a few milky or opal-coloured flakes were formed. No sensible effect was produced by prussiate of potash or super-acetate of lead. I tried in vain to crystallize it by evaporation; indeed, when removed out of a dry atmosphere, it almost immediately resumed its viscidity. I am therefore disposed to consider the contents of these bladders, a kind of liquid sugar, incapable of crystallization, from the little free acid it seems to contain; and that it is secreted from the aqueous juices in

 which

which the bladders float, to minister to the support of the plant during the decay of the old and the formation of the new tubers. The scaly roots of *Lilium candidum* and the tunicate ones of *Narcissus* are provided with similar bladders in their cellular substance, which also are detached and sink in water. In the former they are smaller and more numerous than in *Lathræa;* and those in the upper portions of the scales are chiefly concentrated round the fascicles of spiral sap-vessels. It is worthy of remark, that the cuticle of these scales has also no absorbents, nor do they become green by long exposure to light.

I have already hinted, that the partial shade in which the *Lathræa* is always found cannot be the sole cause of its pale and sickly colour. Many other plants, which grow promiscuously with it, flourish, and severally possess their full and peculiar tints of green*. These all draw their nourishment immediately from the soil; have leaves furnished with cuticular pores, and are powerfully attracted by light. Not so our *Lathræa;* for when its flower-stems have acquired their full altitude, they are always *perpendicular;* and in groups of twenty or thirty in the most umbrageous situations, the rows of flowers (which have always an unilateral direction) are as frequently turned *from* the only side on which light is admitted as *towards* it. I have repeatedly witnessed this singular fact; and have even seen it come up within, though near the door of, a dark hovel, without the stem or its flowers evincing any tendency to incline towards the light. Again, it will be recollected that the various species of *Orobanche* and *Cuscuta* show no inclination to put on the usual vegetable robe of green, though not hidden "from day's garish eye." It is therefore, I conceive, in the structure and

* Such as *Melica uniflora, Sanicula europæa, Allium ursinum, Scilla nutans, Geranium Robertianum,* &c. &c.

mode

mode of growth, that we must endeavour to find a solution of this problem.

By laws which almost universally prevail in the vegetable kingdom, plants imbibe moisture from the soil by means of their radical fibres, and gases and moisture from the atmosphere through the medium of pores in the cuticle of their leaves. These elements are conveyed into the parenchyma, where innumerable and inconceivably delicate organs, stimulated by light and heat, throw off the oxygen and retain the hydrogen and carbon. These essential ingredients at once produce the green colour, and are converted, by a mysterious and hidden process, into the several substances of the vegetable body. Parasitical plants, in one or more respects, and in different ways, are exceptions to these general laws. Though the *Lathræa*, unlike many of its tribe, has leaves amply supplied with absorbents, these organs are doubly concealed in a cold subterranean laboratory, and there destined to breathe in darkness; while the flowering stem,—the only part in contact with the light,—is destitute of those cuticular pores through which air can be admitted, and by means of which the ordinary functions can be performed. The materials and the stimulus are at hand, but for want of the proper apparatus they cannot act. Again: the radicles of the *Lathræa* do not imbibe moisture immediately from the soil, but extract the already assimilated juices of its foster-parent; and whether we suppose these juices to be derived from the inner cortical layers after the accession of carbon through the leaves, or from the alburnum, where they are in a less combined state; they probably contain no free hydrogen to minister to the generation of the green colour. They may also undergo a further chemical change, either in consequence of the partial disease occasioned by the attack of the tubers, or in passing through the substance of the tuber itself. We know that in the dark, plants invariably acquire a pale and sickly tint for want of the stimulus of light to fix the carbon and throw off the oxygen. DeCandolle says, that under such circumstances they are *without* perspiring pores. We also know, that the etiolated parts of some varieties of Celery, the under surface of the leaves of *Nymphæa*, *Hydrocharis*, &c. &c. are tinged with the same beautiful violet hue as the flowering-stems of the *Lathræa*. These striking coincidences render it probable that the cadaverous appearance of our plant is chiefly owing to the absence of leaves and of pores on the flowering-stems, to the condition of the absorbents of the subterranean leaves, and to its subsisting on food elaborated by a foreign agent. But in what manner, and in what degree, each of these causes operates and combines, Chemistry has not yet discovered; nor will she probably be ever able to draw aside the impenetrable veil which checks our researches, and baffles the proud philosophy of man. By the aid of the microscope we can often detect the mechanical contrivances by which various operations in Nature are effected; we can explore her laboratory, determine the elements, inspect the apparatus, and witness the results. But we can no more explain the delicate and subtle chemistry by which, in the vegetable body, the air inhaled by the leaves is assimilated with the juices drawn up through the roots, and converted into woody fibre, and into innumerable secretions, odours, and colours, than we can tell how, in the animal, distinct and discordant fluids are all elaborated from the blood, to support the various functions of life, and the organs of sense and intelligence!

EXPLA-


b
a
1
c
2
a
b
c
4
a
a
5
3
a